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(71) Applicant *(for all designated States except US)*: **GENBAND INC.** [US/US]; 3605 East Plano Parkway, Suite 100, Plano, TX 75074 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **ABRAHAM, Philip** [US/US]; 764 Whitman Place, Allen, TX 75002 (US). **WANG, Yanhua** [CN/US]; 15725 Crown Cove Lane, Frisco, TX 75035 (US).

(74) Agent: HUNT, Gregory, A.; Jenkins, Wilson, Taylor & Hunt, P.a., Suite 1200, University Tower, 3100 Tower Boulevard, Durham, NC 27707 (US).

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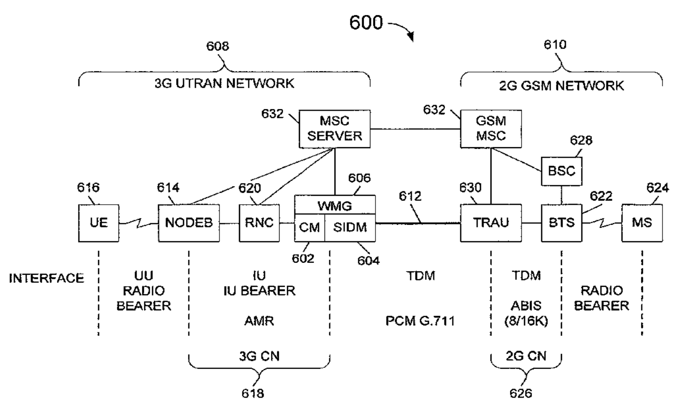
(54) Title: METHODS, SYSTEMS, AND COMPUTER PROGRAM PRODUCTS FOR SILENCE INSERTION DESCRIPTOR (SID) CONVERSION



(57) Abstract: Methods, systems, and computer program products for silence insertion descriptor (SID) conversion are disclosed. According to one aspect, the subject matter described herein includes a method for silence insertion descriptor (SID) conversion. The method includes receiving a wireless frame, the frame identifying a first node as a frame source and a second node as a frame destination; determining whether tandem-free operation (TFO) is applicable; responsive to a determination that TFO is applicable, determining whether the frame is a SID frame; responsive to a determination that the frame is a SID frame, determining whether the SID format used by the first node is incompatible with the SID format used by the second node; and responsive to a determination that the SID format used by the first node is incompatible with the SID format used by the second node, converting the SID frame from the SID format used by the first node to the SID format used by the second node.

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DESCRIPTION

METHODS, SYSTEMS, AND COMPUTER PROGRAM PRODUCTS FOR SILENCE INSERTION DESCRIPTOR (SID) CONVERSION

PRIORITY CLAIM

This application claims the benefit of U.S. Provisional Patent Application Serial No. 60/877,439, filed December 28, 2006; the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The subject matter described herein relates to methods and systems for enhancing the quality of voice calls across mixed-generation wireless networks by obviating, in some circumstances, the need for transcoding and thus avoiding the attendant reduction of voice quality. More particularly, the subject matter described herein relates to methods, systems, and computer program products for silence insertion descriptor (SID) conversion.

BACKGROUND

As wireless communications networks become more pervasive and the number of subscribers continues to increase, wireless bandwidth becomes increasingly scarce. To mitigate this problem, advanced voice compression techniques are used to reduce the bandwidth needed by each voice call. For example, a standard 8-bits per data, 8000 samples per second voice coding, such as 64kbits/s, may be reduced to 8kbits/s or less via coder/decoders (codecs) such as the GSM (Global System for Mobile communication) AMR (Adaptive MultiRate) and EFR (Enhanced Full Rate) codecs and the CDMA (Code Division Multiple Access) EVRC (Enhanced Variable Rate Codec). Codecs typically operate on a collection of samples, which are compressed and sent as a frame of data. Some codecs, for example, divide a voice call into 20ms time slices, sending a frame of data every 20ms.

Some voice codecs define not only a speech compression algorithm but also a silence compression algorithm. It has been estimated that fifty percent or more of a typical telephone conversation is silence – i.e., the part of the conversation during which neither party is speaking. During these periods of silence, transmitting the background noise detected by the cell phone's

microphone would be an unnecessary use of network bandwidth, since the silence (e.g., the background noise) has no information content. However, sending no information during periods of silence has the undesirable side-effect of causing the receiving party to wonder, due to the lack of any sound coming from the sender's phone, whether the sender has hung up or terminated the call.

Therefore, many codecs detect the background noise present at the near-end device and characterize it, such as determining its pitch and volume, and transmit the characterization parameters to the far-end device. At the far-end device, the noise parameters are used to generate a slight background noise, such as soft white noise, recreate the background noise at the near-end device and thus convey the continued presence of the other party on the line. GSM_EFR codecs send what is called a silence insertion descriptor (SID) to the far-end codec. The far-end codec generates natural background noise for the call based on parameters within the received SID frame. Example parameters within the SID frame include line spectral frequency (LSF) and energy gain. With these two pieces of information, roughly equivalent to the pitch and volume of the background noise, respectively, the receiving end is able to recreate the background sound. These SID frames are sent relatively infrequently compared to speech frames. In some codecs, the SID frames are sent at call initiation and again only when the character of the near-end background noise changes significantly.

While the clear advantage to using voice compression is that it uses less bandwidth per call, the disadvantage of using voice compression is that it introduces signal distortion. Whenever a signal is transcoded, or converted from one format to another, there is a potential for introduction of signal distortion. Transcoding refers not only to compression but also to compression/expansion ("companding") operations, such as A-law and mu-law encoding/decoding. As shown below, in a typical mobile-to-mobile call there may be many transcoding steps, each of which having the potential to degrade the voice quality of the call.

Figure 1 is a block diagram illustrating a conventional mobile-to-mobile call. Caller's cell phone **100** is connected via a radio frequency (RF) interface

to the nearest cell phone tower and associated base station subsystem (BSS1 **102**). Caller's cell phone **100** typically uses a voice encoder to compress caller's voice from 64~128kbit/s to 12.2kbit/s, for example, before transmitting the compressed speech data to the BSS1 **102**. BSS1 **102** provides the interface between the RF network and the wireline network. BSS1 **102** may send the speech data to a transcoded rate adaptive unit (TRAU1 **104**), which may decode the compressed speech data into uncompressed 8~16bit per sample, 8000 sample per second audio data. TRAU1 **104** may transmit the uncompressed data across the network, as shown in Figure 1, but typically it will re-encode the uncompressed voice data using a compression/expansion algorithm, such as A-law or mu-law, to boost the signal-to-noise ratio of the signal being transmitted, creating a 64kbits/s PCM G.711 data stream. In other words, TRAU1 **104** may transcode the voice data from one encoding format to another, such as from 3G_GSM_AMR to G.711. TRAU1 **104** may forward the speech data across the phone network to TRAU2 **106**. TRAU2 **106** may transcode the speech data into the compressed format used by the destination network. For example, TRAU2 **106** may convert the speech data from G.711 to 2G_GSM_EFR. TRAU2 **106** may send the transcoded speech data to the destination network's base station subsystem, BSS2 **108**. BSS2 **108** may transmit the re-encoded speech data to Callee's cell phone **110**.

In summary, the voice data may be encoded (and decoded) several times along the path between caller's cell phone **100** and callee's cell phone **110**: encoding using the source codec by caller's cell phone **100**, encoding using the intermediate codec by TRAU1 **104**, and encoding using the destination codec by TRAU2 **106**. Since both TRAU1 **104** and TRAU2 **106** must agree on an intermediate format, which may be 64kbit/s mu-law PCM data, for example, TRAU1 **104** and TRAU2 **106** are said to be operating in tandem, and are commonly referred to as being a tandem pair.

As used herein, the term "internal format" refers to the intermediate format which the tandem pair uses to communicate data with each other, and the term "external format" refers to the format that each member of the tandem pair uses to communicate data with its respective network. The respective external formats may incompatible, as can be seen in Figure 1, in which the

external format for TRAU1 **104** achieves a compression of 12.2kbits per second, while the external format TRAU2 **106** achieves a compression of 16kbits per second.

Each encoding step – by caller's cell phone **100**, BSS1 **102**, and BSS2 **108** – may introduce additional signal distortion, which degrades the overall quality of the voice call. One way to avoid the degradation of voice signal quality in a mobile-to-mobile scenario is to reduce the number of transcoding steps performed. For example, if the external format used by the caller's base station is the same or compatible with the external format used by the callee's base station, there may be no need to transcode to an intermediate format. In other words, there may be no need for a tandem pair to perform transcoding. Operation in such a mode is commonly referred to as "tandem-free operation", or TFO. Figure 2 illustrates an example of a network operating in TFO mode. In conventional systems, two codecs are the same or compatible if they use the same speech and silence compression algorithms and the same bit rates.

Figure 2 is a block diagram illustrating a conventional mobile-to-mobile call using tandem-free operation. As stated above, TFO mode is possible only if the two mobile networks use the same or compatible external format. Thus, in Figure 2 the codec used by BSS1 **102** to communicate with caller's cell phone **100** is the same as, or compatible with, the codec used by BSS2 **108** to communicate with callee's cell phone **110**. For example, BSS1 **102** and BSS2 **108** may use codecs that use the same speech and silence compression algorithms and same bit rate. In this case, it is unnecessary for TRAU1 **104** to transode the speech data into an internal format, such as G.711, before sending the speech data across the network to TRAU2 **106**, and vice versa. Instead, TRAU1 **104** and TRAU2 **106** may send the speech data to without transcoding, avoiding two transcoding steps. Furthermore, BSS2 **108** may transmit the encoded speech data over its RF interface directly to the callee's mobile phone, thus avoiding two additional transcoding steps: the transcoding of data as it passes from the radio interface to the wired network interface in each of the respective wireless networks. In summary, by not transcoding voice data to and from an intermediate format (i.e., G.711), degradation of voice quality due to introduced signal distortion is avoided. The TFO principle

may apply anywhere along the network path in which transcoding to an internal codec may be eliminated by agreement between nodes that use the same external codec.

For TFO to work, however, additional requirements must be met. One requirement is that the nodes or network entities be able to support TFO, which means that the nodes need be able to communicate with each other regarding the TFO stream. For example, the nodes may need to negotiate a TFO link, monitor link status, or provide fallback procedures in case of TFO interruption. Typically, in-band signaling is used for communication of TFO messages, since the compressed voice data stream uses a fraction of the bandwidth and thus makes bits available for a control channel. A common practice is to map the control channel onto the least significant bit or bits of the 8-bit, 64kbit/s channel. This causes only a slight degradation of quality of uncompressed voice data, and causes no degradation of quality of the compressed voice data. Thus, the bearer channel must support in-band signaling. Another requirement is that external codecs should be the same or likewise compatible; otherwise, any benefit to skipping the intermediate transcoding step may be reduced by the need to convert from one external codec to another external codec.

An additional challenge is raised when attempting to implement TFO for a mobile-to-mobile voice call that crosses a boundary between 2G wireless networks and 3G wireless networks: there may be a difference between the 2G version of a codec and its 3G equivalent. Figure 3 illustrates such an example.

Figure 3 is a block diagram illustrating a conventional mobile-to-mobile call that crosses the boundary between 2G and 3G wireless networks. Although BSS1 **102** and BSS2 **108** both use the GSM_EFR (enhanced full rate) codec, BSS1 **102** is a 3G network, and therefore uses the 3G version of the GSM_EFR codec, while BSS2 **108** is a 2G mobile network, and therefore uses the 2G version of the GSM_EFR codec. Although the 2G and 3G versions of the GSM_EFR codec have the same 12.2kbits/s rate for voice compression, their silence insertion description frames are incompatible. To address this incompatibility, conventional networks perform at least one transcoding operation, from 3G_GSM_EFR to 2G_GSM_EFR and vice versa. In practice, conventional systems, such as the one shown in Figure 3, will

perform not one but two transcoding operations, into and out of the preferred or native format used by the network backbone. In Figure 3, for example, TRAU1 **104** and TRAU2 **106** may operate in tandem to transcode into and out of a common internal codec format such as the 12.2kbit/s AMR format. Thus, although the 2G_GSM_EFR and 3G_GSM_EFR codecs are essentially identical, the incompatible silence insertion description frames prevent efficient mobile to mobile communication, which introduces distortion into the call.

Figure 4 illustrates the general frame format for a conventional 3G EFR frame. The radio frequency channel index (RFCI) field indicates the type of frame. An RFCI value of "3" indicates that the frame is a SID frame. For a SID frame, the LSF and energy gain data will be contained in the frame payload part, which starts at octet 3.

Figure 5 illustrates the general frame format for a conventional 2G EFR frame. A 2G EFR frame includes a payload field and four subframes. The LSF data is located in the payload field, in bits 1 – 38. The energy gain data is located in sub-frame 1, in bits 87 – 91. For a 2G EFR SID frame, sub-frames 2 through 4 do not contain any SID-specific information.

Unlike the 3G version of an EFR frame, the 2G EFR frame does not include a frame type field. Rather, a SID frame type is indicated by a particular bit pattern of sub-frame 1. The particular bit pattern is also called a frame signature. The frame signature must be analyzed in order to determine whether an incoming 2G EFR frame is a SID frame.

As can be seen from Figure 5 and Figure 4, the 2G GMS SID frame is 244 bits long, while the 3G UMTS SID frame is 43 bits long. This incompatibility is significant enough to prevent tandem-free operation between two otherwise compatible codecs. Referring back to Figure 3, the incompatibility of the SID frames may force TRAU1 **104** and TRAU2 **106** to operate in tandem mode and use an intermediate format, such as a 12.2kbit/s AMR. Thus, in a mobile-to-mobile voice call between a 2G network and a 3G network, tandem-free operation may not be possible, and the benefits of TFO, such as increased voice quality, may be unavailable.

Thus, there is a need for a way to enable TFO operation between 2G and 3G networks that use codecs with similar speech compression algorithms

and bit rates but which have dissimilar SID frame formats. In particular, there is a need for methods, systems, and computer program products for silence insertion descriptor (SID) conversion.

SUMMARY

According to one aspect, the subject matter described herein includes a method for silence insertion descriptor (SID) conversion. The method includes receiving a wireless frame, the frame identifying a first node as a frame source and a second node as a frame destination; determining whether tandem-free operation (TFO) is applicable; responsive to a determination that TFO is applicable, determining whether the frame is a SID frame; responsive to a determination that the frame is a SID frame, determining whether the SID format used by the first node is incompatible with the SID format used by the second node; and responsive to a determination that the SID format used by the first node is incompatible with the SID format used by the second node, converting the SID frame from the SID format used by the first node to the SID format used by the second node.

As used herein, the term "wireless frame" refers to data that originates from a device in a wireless mobile network, is organized into a frame, and contains voice or other media traffic. Voice traffic data may include both active speech (i.e., when at least one party is talking) and silence (i.e., when no party is talking), and may be compressed or uncompressed.

According to another aspect, the subject matter described herein includes a method for silence insertion descriptor (SID) conversion. The method includes receiving a wireless frame, the frame identifying a first node as a frame source and a second node as a frame destination; identifying a first codec used by the first node and a second codec used by the second node, and determining whether one of the first and second codecs comprise a second generation global system for mobile enhanced full rate (2G_GSM_EFR) codec and the other of the first and second codes comprises a third generation global system for mobile enhanced full rate (3G_GSM_EFR) codec; responsive to a determination that the codecs comprise a 2G_GSM_EFR codec and a 3G_GSM_EFR codec, determining whether the frame is a SID frame;

responsive to a determination that the frame is a SID frame, determining whether the SID format used by the first node is incompatible with the SID format used by the second node; responsive to a determination that the SID format used by the first node is incompatible with the SID format used by the second node, converting the frame from the SID format used by the first node to the SID format used by the second node and sending the converted SID frame to the second node.

According to yet another aspect, the subject matter described herein includes a system for silence insertion descriptor (SID) conversion. The system includes a control module for receiving a wireless frame, the frame identifying a first node as a frame source and a second node as a frame destination, and for determining whether tandem-free operation (TFO) is applicable. The system also includes a SID conversion module, operatively associated with the control module, for determining whether the frame is a SID frame, and, responsive to a determination that the frame is a SID frame, determining whether a SID format used by the first node is incompatible with a SID format used by the second node, and, responsive to a determination that the SID format used by the first node is incompatible with the SID format used by the second node, converting the frame from the SID format used by the first node to the SID format used by the second node and sending the converted frame to the second node.

The subject matter described herein for silence insertion description conversion may be implemented in hardware, software, firmware, or any combination thereof. As such, the terms “function” or “module” as used herein refer to hardware, software, and/or firmware for implementing the feature being described. In one exemplary implementation, the subject matter described herein may be implemented using a computer program product comprising computer executable instructions embodied in a computer readable medium.

Exemplary computer readable media suitable for implementing the subject matter described herein include disk memory devices, chip memory devices, programmable logic devices, and application specific integrated circuits. In addition, a computer program product that implements the subject matter described herein may be located on a single device or computing platform or may be distributed across multiple devices or computing platforms.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the subject matter described herein will now be explained with reference to the accompanying drawings of which:

Figure 1 is a block diagram illustrating a conventional mobile-to-mobile call;

Figure 2 is a block diagram illustrating a conventional mobile-to-mobile call using tandem-free operation;

Figure 3 is a block diagram illustrating a conventional mobile-to-mobile call that crosses the boundary between 2G and 3G wireless networks;

Figure 4 illustrates the general frame format for a conventional 3G EFR frame;

Figure 5 illustrates the general frame format for a conventional 2G EFR frame;

Figure 6 is a block diagram illustrating an exemplary system for silence insertion descriptor (SID) conversion in accordance with an embodiment of the subject matter described herein;

Figure 7 is a flow chart illustrating an exemplary process for silence insertion descriptor conversion in accordance with an embodiment of the subject matter described herein;

Figure 8 a flow chart illustrating an exemplary process for converting a SID frame according to an embodiment of the subject matter described herein; and

Figure 9 is a message flow diagram illustrating the steps of an exemplary process for determining whether TFO is applicable according to an embodiment of the subject matter described herein.

DETAILED DESCRIPTION

In accordance with the subject matter disclosed herein, methods, systems, and computer program products for silence insertion descriptor (SID) conversion are provided. Where a mobile-to-mobile call spans mobile networks that use the same or compatible speech compression algorithms and bit rates but incompatible silence insertion descriptors, an intermediate transcoding step is avoided by efficiently detecting SID frames in the format used by the source

network, extracting the SID information contained within the incoming SID frames, and using the extracted information to create outgoing SID frames of a format used by the destination network. Speech frames may simply be forwarded without transcoding. By avoiding transcoding into an intermediate format, distortion otherwise caused by those transcoding steps is eliminated, improving the sound quality of the call.

Figure 6 is a block diagram illustrating an exemplary system for silence insertion descriptor (SID) conversion in accordance with an embodiment of the subject matter described herein. In one embodiment, system **600** may contain a control module **602** for receiving a wireless frame, the frame identifying a first node as a frame source and a second node as a frame destination, and a SID conversion module **604**, operatively associated with control module **602**, for determining whether tandem-free operation (TFO) is applicable, and, responsive to a determination that TFO is applicable, determining whether the frame is a SID frame, and, responsive to a determination that the frame is a SID frame, determining whether a SID format used by the first node is incompatible with a SID format used by the second node, and, responsive to a determination that the SID format used by the first node is incompatible with the SID format used by the second node, converting the frame from the SID format used by the first node to the SID format used by the second node and sending the converted frame to the second node.

In one embodiment, control module **602** and SID conversion module **604** may be components of a wireless media gateway WMG **606** for communicating messages between a packet-based mobile wireless network MWN1 **608** and a TDM-based mobile wireless network MWN2 **610** via a TDM trunk **612**.

In one embodiment, MWN1 **608** may be a 3G UMTS terrestrial radio access network (UTRAN), including a UMTS base transceiver station (BTS), referred to as a NodeB **614**, for providing a radio communications link between mobile user equipment **616** and the 3G core network **618**. A radio network controller RNC **620** manages a group of NodeBs.

In one embodiment, MWN2 **610** may be a 2G GSM network, including a base transceiver station (BTS **622**) for providing a radio communications link between mobile stations **624** and the 2G core network **626**. A base station

controller (BSC **628**) manages a group of BTSs. MWN2 **610** may include a transcoding rate adapter unit TRAU **630** for transcoding from a codec format used by TDM trunk **612** into a codec format used by MWN2 **610**. Furthermore, each wireless network may have one or more mobile switching centers (MSC **632**) which handle the signaling messages for call setup.

In addition to converting messages from packet to TDM format, WMG **606** may also transcode messages. For example, MWN1 **608** may use a codec, such as a 3G GSM AMR or EFR codec, to compress bearer data transmitted within 3G core network **618**, in which case WMG **606** may need to transcode the compressed data into an uncompressed format, such as PCM data, and optionally transcode again into a format such as G.711, which uses a companding algorithm, such as A-law or mu-law, to improve the signal to noise ratio of data transmitted across TDM trunk **612**. Similarly, TRAU **630** may transcode the PCM G.711 data into uncompressed PCM data, and then recompress the data using a codec used by MWN2 **610**, such as Abis or 2G GSM EFR.

Because SID conversion module **604** is capable of converting between incompatible SID formats, WMG **606** and TRAU **630** may enter into a tandem-free operation (TFO) mode; in this case, WMG **606** may convert wireless frames from packet format to TDM format without transcoding into an intermediate codec format used by TDM trunk **612**, and TRAU **630** may similarly avoid the transcoding step and simply pass the wireless frames through to BTS **622** without modification.

In conventional systems, WMG **606** and TRAU **630** would not be able to enter TFO mode if the codec used by MWN1 **608** and MWN2 **610** are the 3G and 2G versions, respectively, of the GSM EFR codec. Here, however, TFO mode may be taken advantage of if the respective codecs have the same speech compression algorithm and bit rate, but the formats of their respective SID frames differ, as is the case with the GSM EFR codecs. The operation of system **600** will now be described.

Figure 7 is a flow chart illustrating an exemplary process for silence insertion descriptor conversion in accordance with an embodiment of the subject matter described herein.

At block **700**, a wireless frame is received, the frame identifying a first node as a frame source and a second node as a frame destination. For example, WMG **606** may receive a wireless frame that originates from caller **616** and is intended for callee **624**.

At block **702**, it is determined whether tandem-free operation (TFO) is applicable or not. For example, as part of the call setup, RNC **620** and its TFO peer, TRAU **630**, may exchange information about the codecs supported by the respective networks MWN1 **608** and MWN2 **610**, through signaling messages sent via MSCs **632**. To determine whether TFO is applicable, control module **602** may determine whether the speech compression algorithms and bit rates of the respective codecs are the same. For example, at call setup, WMG **606** may analyze call setup signaling messages to identify codecs used by the incoming and outgoing call legs in order to determine whether the codecs are the same or compatible. If so, WMG **606** may store an indication that TFO is applicable, and control module **602** may read this indication to determine whether or not TFO is applicable. Alternatively, SID conversion module **604** may read this indication to determine whether or not TFO is applicable. This process is described in more detail in Figure 9, below. If TFO is not applicable, the process moves to block **704**, in which the frame may be transcoded into an intermediate format used by TDM trunk **612**, and then to block **706**, in which the frame, transcoded in this case, is sent to the frame destination. However, if TFO is applicable, the process moves to block **708**.

At block **708**, it is determined whether the wireless frame is a SID frame. For example, if the received frame is a 43-bit 3G_GSM_EFR frame, SID conversion module **604** may look for a value of “3” in the radio frequency channel index (RFCI) field of the frame, indicating a 3G SID frame. On the other hand, if the received frame is a 244-bit 2G_GSM_EFR frame, SID conversion module **604** may look for a specific pattern of 95 bits in the frame set to “1”, indicating that the frame is a 2G SID frame. If the wireless frame is not a SID frame, the process moves to block **706**, in which the frame is sent, without transcoding, to the frame destination. However, if the frame is a SID frame, the process moves to block **710**.

At block **710**, it is then determined whether the format of a SID frame used by the first node is incompatible with the SID format used by the second node. For example, SID conversion module **604** may maintain information about the call from caller **616** to callee **624**, including information about the codec formats negotiated between RNC **620** and BSC **628**, and use that information to determine whether the SID formats are compatible or not. In one embodiment, the first and second nodes may be the respective air interfaces NodeB **614** and BTS **622**. Alternatively, the first and second nodes may be the mobile devices themselves, UE **616** and MS **624**. If the SID frame formats are compatible, the process moves to block **706**, in which the SID frame is sent, without conversion, to the frame destination. However, if the SID frame formats are incompatible, the process moves to block **712**.

At block **712**, the SID frame is converted from the SID format used by the first node to the SID format used by the second node. For example, if SID conversion module **604** determines that the SID formats are incompatible, it may use the procedure illustrated in Figure 8, below, to convert the SID frame from into a format used by the destination node. The process then moves to block **706**, in which the converted SID frame is sent to the frame destination.

Figure 8 a flow chart illustrating an exemplary process for converting a SID frame according to an embodiment of the subject matter described herein.

At block **800**, SID conversion module **604** determines the SID format used by the source node. For example, SID conversion module **604** may be able to determine the SID format simply from the length of the frame: a 3G SID frame is 43 bits long while a 2G SID frame is 244 bits long.

At block **802**, SID conversion module **604** chooses a conversion method based on the source format. For example, if SID conversion module **604** determines that the frame is a 2G SID frame, control flow goes to block **804**, and if the frame is a 3G SID frame, control flow goes to block **808**.

At block **804**, SID conversion module **604** generates an output SID frame from a 3G SID template as illustrated in Figure 4.

At block **806**, SID conversion module **604** populates the output SID frame in the following way, using field names described in Figures 4 and 5 for reference: bits S1-S8 of the 2G SID frame are copied into bits P1-P38 of the

3G SID template, and bits S87-S91 are copied into bits P39-P43. The RFCI field is then set with the value for indicating that the frame is a 3G SID frame. Control flow then goes continues to block **712** in Figure 7, in which the generated output SID frame is sent to the destination node.

At block **808**, SID conversion module **604** generates an output SID frame from a 2G SID template as illustrated in Figure 5.

At block **810**, SID conversion module **604** populates the output SID frame in the following way, again using field names described in Figures 4 and 5 for reference: bits P1-P8 of the 3G SID frame are copied into bits S1-S38 of the 2G SID template, bits P39-P43 are copied into bits S87-S91, and bits S39-S86 of the 2G SID template are filled with the GSM_EFR_SID codeword. Control flow then goes continues to block **712** in Figure 7, in which the generated output SID frame is sent to the destination node.

Figure 9 is a message flow diagram illustrating the steps of an exemplary process for determining whether TFO is applicable according to an embodiment of the subject matter described herein. Figure 9 illustrates the process for negotiating TFO between a 2G network (GSM) and a 3G network (UMTS). TFO is negotiated between two end devices during call setup: a TFO peer on the 2G side, TRAU **630** and RNC **620** on the 3G side. In one embodiment, wireless media gateway WMG **606** is controlled by its mobile switching center MSC **632** via a proprietary protocol EGCP (Extended Gateway Control Protocol). Alternatively, other media gateway control protocols, such as MEGACO/H.248 and MGCP, may be used.

The first pair of messages (messages **900** and **902**) are exchanged by MSC **632** and WMG **606** to establish a wireless call at WMG **606**. Once the media gateway connection is established, the 3G end device communicates its AMR rate information to the media gateway (messages **904** and **906**). A similar process (not shown) establishes a connection between the 2G end device and the closest BTS **622**. A media path is established between RNC **620** and TRAU **630**. At this point, on the 3G side, the media stream in AMR format is transcoded into PCM at the media gateway and vice versa, without TFO (data stream **908**). The two end devices may then start the TFO negotiation.

As the first step of TFO negotiation, WMG **606** sends a notification event (messages **910** and **912**) to let that TFO negotiation may commence. RNC **620** sends rate and rate adjustment information to WMG **606** (messages **914** and **916**), which passes on the information to the 2G side and starts TFO negotiation (**918**). During the negotiation process, RNC **620** may negotiate a new AMR rate with the 2G side (**920**). If the rates of 3G side can be supported by the 2G side and SID frames also match (**922**), then TFO negotiation concludes successfully (**924**), and WMG **606** notifies MSC **632** of this fact (messages **926** and **928**). As stated above, WMG **606** may store an indication that TFO is in use for the particular call. This indication may be read by control module **602**, or in alternative embodiments, by SID conversion module **604**, to determine whether TFO is applicable to incoming wireless frame, as illustrated in step **702** of Figure 7.

It will be understood that various details of the subject matter described herein may be changed without departing from the scope of the subject matter described herein. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation.

CLAIMS

What is claimed is:

1. A method for silence insertion descriptor (SID) conversion, the method comprising:

   receiving a wireless frame, the frame identifying a first node as a frame source and a second node as a frame destination;

   determining whether tandem-free operation (TFO) is applicable;

   responsive to a determination that TFO is applicable, determining whether the frame is a SID frame;

   responsive to a determination that the frame is a SID frame, determining whether the SID format used by the first node is incompatible with the SID format used by the second node; and

   responsive to a determination that the SID format used by the first node is incompatible with the SID format used by the second node, converting the frame from the SID format used by the first node to the SID format used by the second node and sending the converted SID frame to the second node.

2. The method of claim 1 wherein determining whether TFO is applicable includes determining whether a speech compression algorithm and data rate used by the first node is the same as a speech compression algorithm and data rate used by the second node.

3. The method of claim 1 wherein determining whether the input frame is a SID frame includes determining, based on the contents of a frame index field indicator, whether the input frame is a SID frame for a third generation (3G) network.

4. The method of claim 1 wherein determining whether the input frame is a SID frame includes determining, based on a designated bit pattern, whether the input frame is a SID frame for a second generation (2G) network.

5. The method of claim 1 wherein converting the SID frame includes:

locating line spectral frequency information and energy gain information within the frame;

extracting the line spectral frequency and energy gain information from the frame; and

generating, as the converted SID frame, a wireless frame of the SID format used by the second node and containing the extracted line spectral frequency and energy gain information.

6. A method for silence insertion descriptor (SID) conversion, the method comprising:

receiving a wireless frame, the frame identifying a first node as a frame source and a second node as a frame destination;

identifying a first codec used by the first node and a second codec used by the second node, and determining whether one of the first and second codecs comprises a second generation global system for mobile enhanced full rate (2G_GSM_EFR) codec and the other of the first and second codecs comprises a third generation global system for mobile enhanced full rate (3G_GSM_EFR) codec;

responsive to a determination that the codecs comprise a 2G_GSM_EFR codec and a 3G_GSM_EFR codec, determining whether the frame is a SID frame;

responsive to a determination that the frame is a SID frame, determining whether the SID format used by the first node is incompatible with the SID format used by the second node; and

responsive to a determination that the SID format used by the first node is incompatible with the SID format used by the second node, converting the frame from the SID format used by the first node to the SID format used by the second node and sending the converted SID frame to the second node.

7. The method of claim 6 wherein determining whether the input frame is a SID frame includes determining, based on the contents of a frame index

field indicator, whether the input frame is a SID frame for a third generation (3G) network.

8. The method of claim 6 wherein determining whether the input frame is a SID frame includes determining, based on a designated bit pattern, whether the input frame is a SID frame for a second generation (2G) network.

9. The method of claim 6 wherein converting the SID frame includes:

locating line spectral frequency information and energy gain information within the frame;

extracting the line spectral frequency and energy gain information from the frame; and

generating, as the converted SID frame, a wireless frame of the SID format used by the second node and containing the extracted line spectral frequency and energy gain information.

10. A system for silence insertion descriptor (SID) conversion, the system comprising:

a control module for receiving a wireless frame, the frame identifying a first node as a frame source and a second node as a frame destination, and for determining whether tandem-free operation (TFO) is applicable; and

a SID conversion module, operatively associated with the control module, for determining whether the frame is a SID frame, and, responsive to a determination that the frame is a SID frame, determining whether a SID format used by the first node is incompatible with a SID format used by the second node, and, responsive to a determination that the SID format used by the first node is incompatible with the SID format used by the second node, converting the frame from the SID format used by the first node to the SID format used by the second node and sending the converted frame to the second node.

11. The system of claim 6 wherein the SID conversion module is adapted to determine whether a speech compression algorithm and data rate used

by the first node is the same as a speech compression algorithm and data rate used by the second node.

12. The system of claim 6 wherein the SID conversion module is adapted to determine, based on the contents of a frame index field indicator, whether the frame is a SID frame for a third generation (3G) network.

13. The system of claim 6 wherein the SID conversion module is adapted to determine, based on a designated bit pattern, whether the frame is a SID frame for a second generation (2G) network.

14. The system of claim 6 wherein the SID conversion module is adapted to convert the SID frame by:

locating line spectral frequency information and energy gain information within the frame;

extracting the line spectral frequency and energy gain information from the frame;

generating, as the converted SID frame, a wireless frame of the SID format used by the second node and containing the extracted line spectral frequency and energy gain information.

15. A computer program product comprising computer executable instructions embodied in a computer readable medium for performing steps comprising:

receiving a wireless frame, the frame identifying a first node as a frame source and a second node as a frame destination;

determining whether tandem-free operation (TFO) is applicable;

responsive to a determination that TFO is applicable, determining whether the frame is a SID frame;

responsive to a determination that the frame is a SID frame, determining whether the SID format used by the first node is incompatible with the SID format used by the second node;

responsive to a determination that the SID format used by the first node is incompatible with the SID format used by the second node, converting the frame from the SID format used by the first node to the

SID format used by the second node and sending the converted SID frame to the second node.

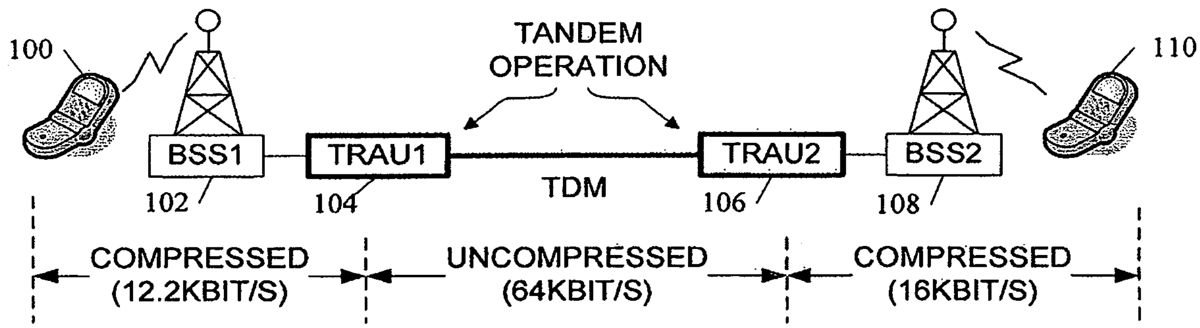


FIG. 1
(PRIOR ART)

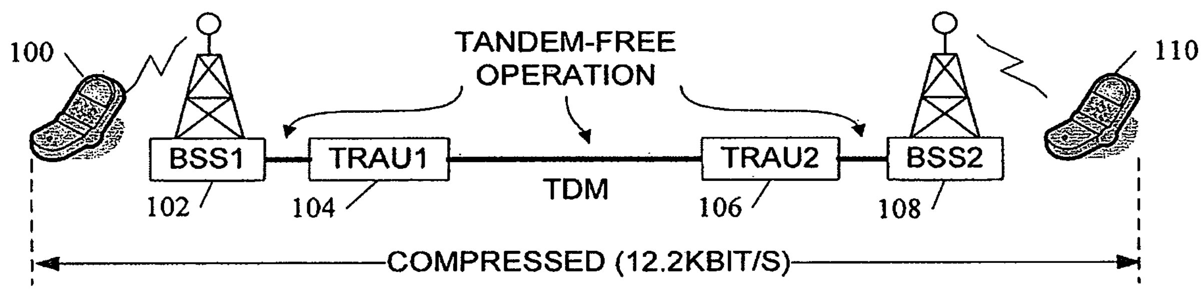


FIG. 2
(PRIOR ART)

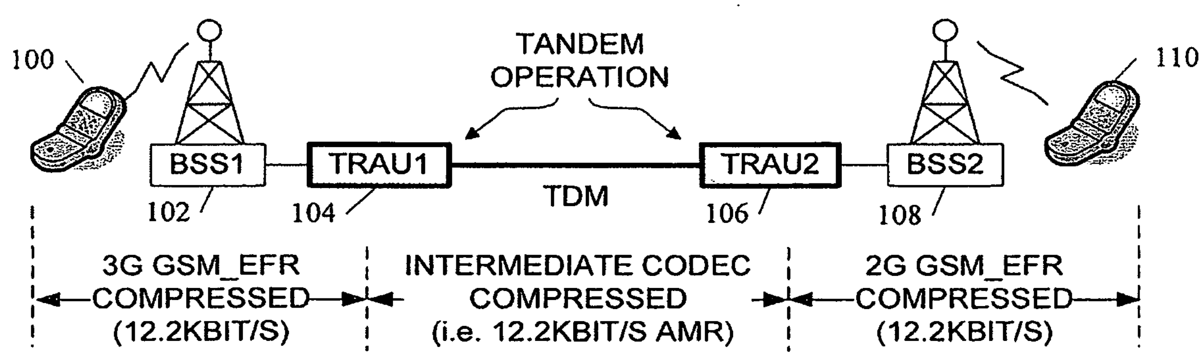
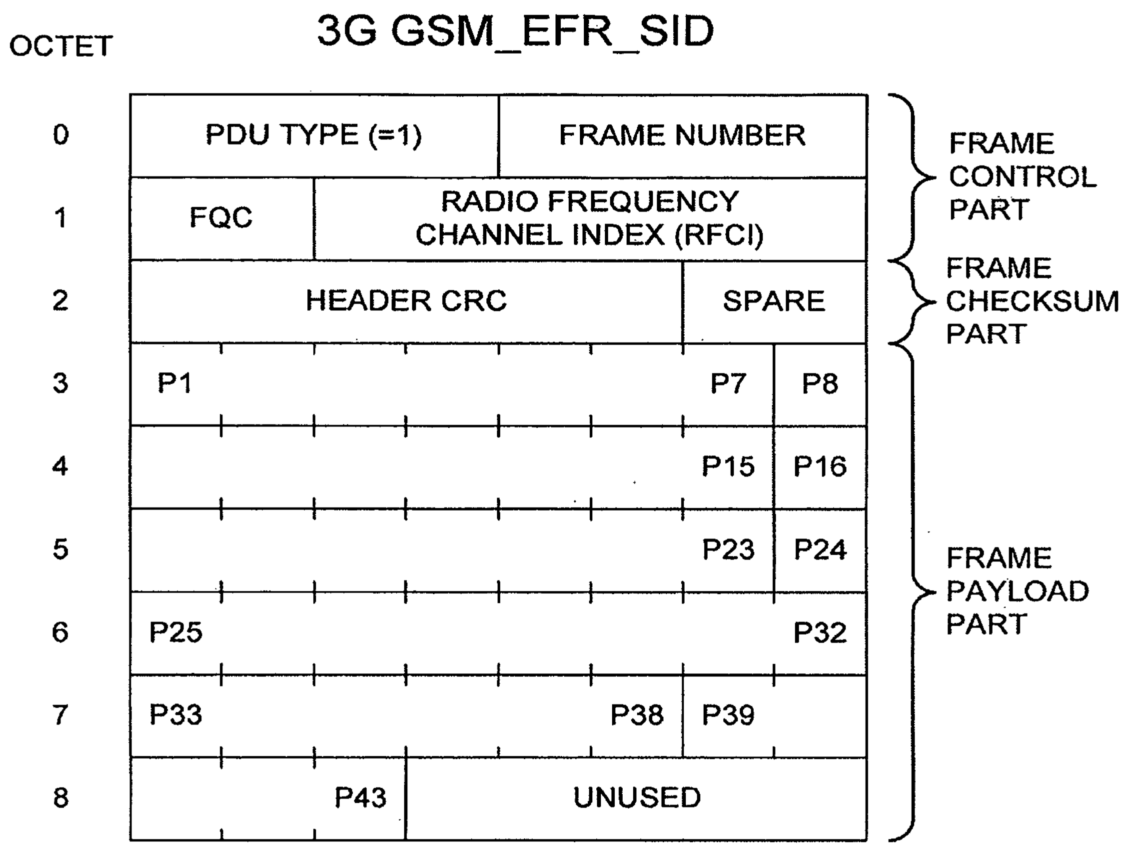


FIG. 3
(PRIOR ART)



P1 – P7	INDEX OF 1ST LSF SUBMATRIX
P8 – P15	INDEX OF 2ND LSF SUBMATRIX
P16 – P23	INDEX OF 3RD LSF SUBMATRIX
P24	SIGN OF 3RD LSF SUBMATRIX
P25 – P32	INDEX OF 4TH LSF SUBMATRIX
P33 – P38	INDEX OF 5TH LSF SUBMATRIX
P39 – P43	FIXED CODEBOOK GAIN

FIG. 4
(PRIOR ART)

2G GSM_EFR_SID

MSB – LSB	W	FIELD NAME
S1 – S38	38	SID PAYLOAD
S39 – S91	53	SUB-FRAME 1
S92 – S141	50	SUB-FRAME 2
S142 – S194	53	SUB-FRAME 3
S195 – S244	50	SUB-FRAME 4

SID PAYLOAD	S1 – S7	7	INDEX OF 1ST LSF SUBMATRIX
	S8 – S15	8	INDEX OF 2ND LSF SUBMATRIX
	S16 – S23	8	INDEX OF 3RD LSF SUBMATRIX
	S24	1	SIGN OF 3RD LSF SUBMATRIX
	S25 – S32	8	INDEX OF 4TH LSF SUBMATRIX
	S33 – S38	6	INDEX OF 5TH LSF SUBMATRIX
SUB-FRAME 1	S39 – S47	9	ADAPTIVE CODEBOOK INDEX
	S48 – S51	4	ADAPTIVE CODEBOOK GAIN
	S52	1	SIGN OF 1ST AND 6TH PULSES
	S53 – S55	3	POSITION OF 1ST PULSE
	S56	1	SIGN OF 2ND AND 7TH PULSES
	S57 – S59	3	POSITION OF 2ND PULSE
	S60	1	SIGN OF 3RD AND 8TH PULSES
	S61 – S63	3	POSITION OF 3RD PULSE
	S64	1	SIGN OF 4TH AND 9TH PULSES
	S65 – S67	3	POSITION OF 4TH PULSE
	S68	1	SIGN OF 5TH AND 10TH PULSES
	S69 – S71	3	POSITION OF 5TH PULSE
	S72 – S74	3	POSITION OF 6TH PULSE
	S75 – S77	3	POSITION OF 7TH PULSE
	S78 – S80	3	POSITION OF 8TH PULSE
	S81 – S83	3	POSITION OF 9TH PULSE
	S84 – S86	3	POSITION OF 10TH PULSE
	S87 – S91	5	FIXED CODEBOOK GAIN
SUB-FRAME 2	S92 – S97	6	ADAPTIVE CODEBOOK INDEX (RELATIVE)
	S98 – S141	8	SAME DESCRIPTION AS BITS S48 - S91
SUB-FRAME 3	S142 – S194	8	SAME DESCRIPTION AS BITS S39 - S91
SUB-FRAME 4	S195 – S244	8	SAME DESCRIPTION AS BITS S92 - S141

FIG. 5 (PRIOR ART)

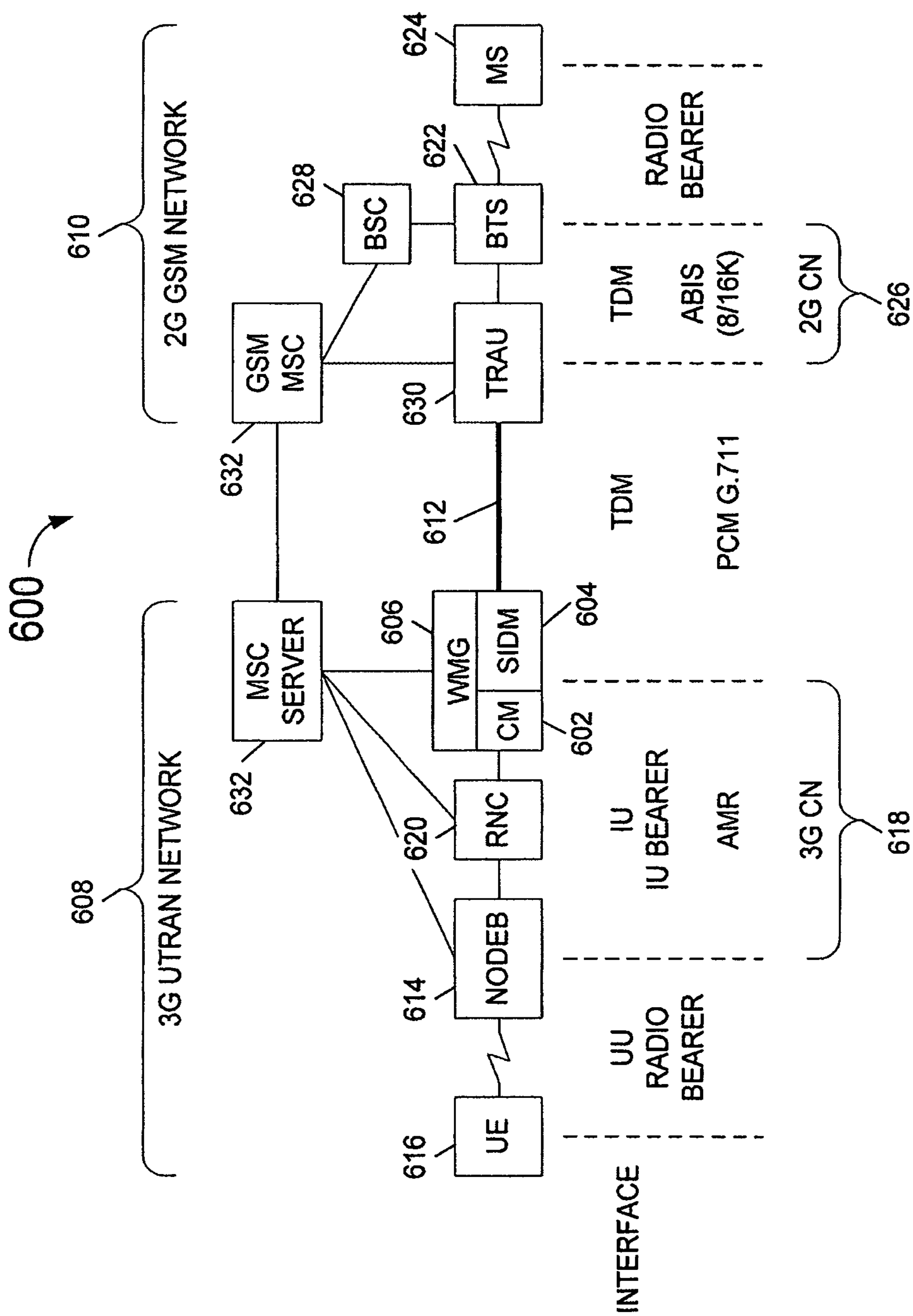

600
610
2G GSM NETWORK
608
3G UTRAN NETWORK
MS
624
BTS
622
BSC
628
GSM MSC
632
TRAU
630
612
MSC SERVER
632
WMG
606
SIDM
604
CM
602
RNC
620
NODEB
614
UE
616
RADIO BEARER
TDM
ABIS (8/16K)
2G CN
626
TDM
PCM G.711
IU
IU BEARER
AMR
3G CN
618
UU
RADIO BEARER
INTERFACE

FIG. 6

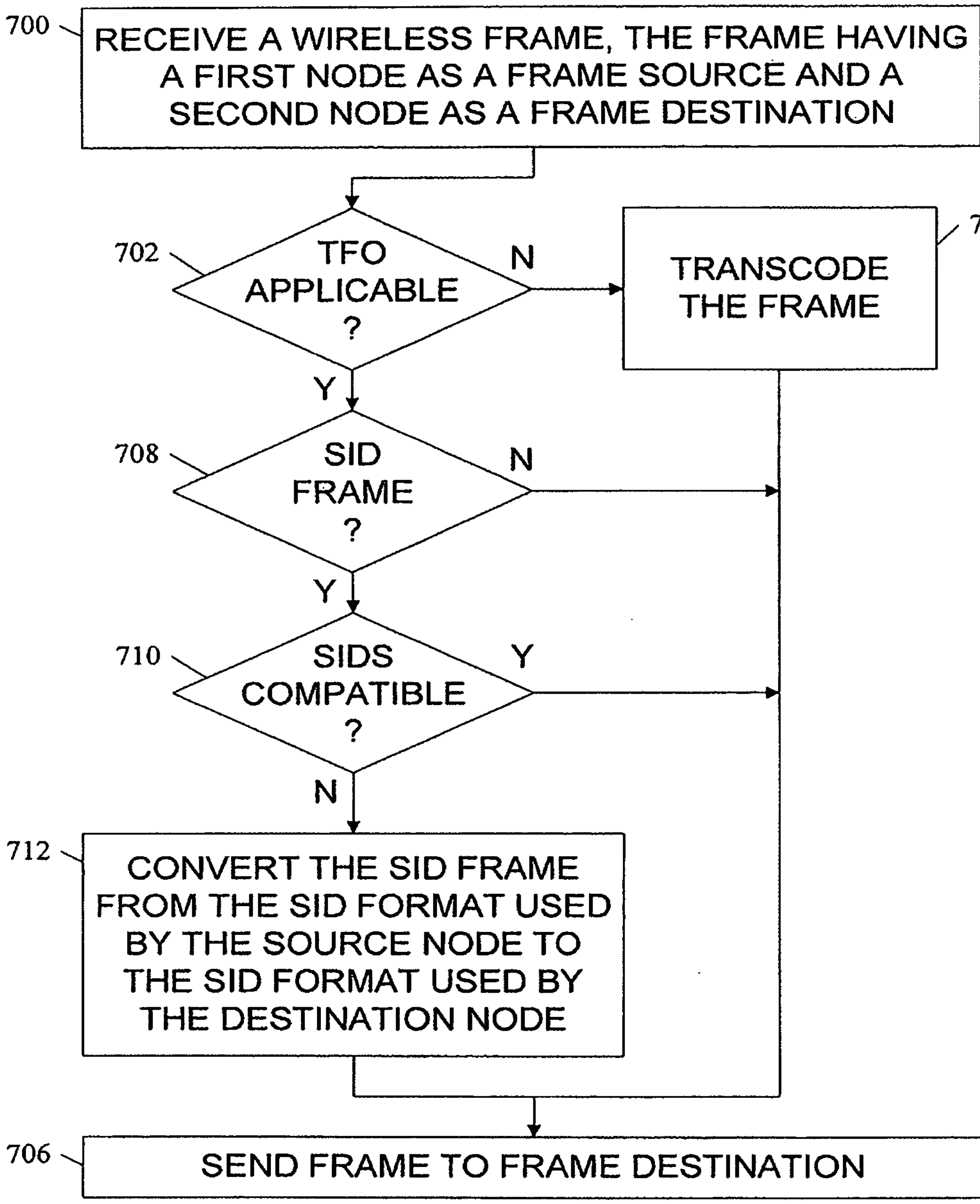
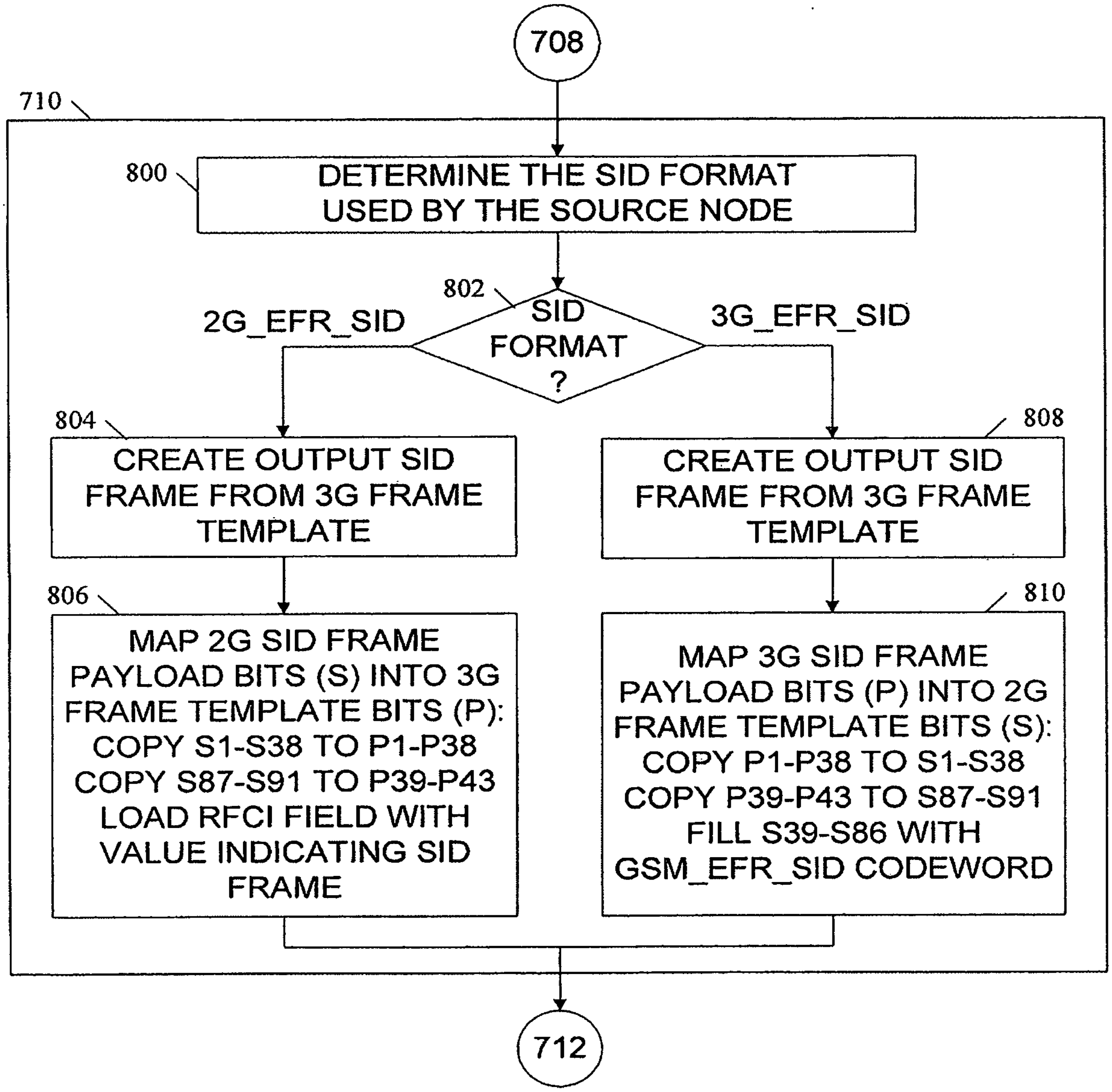

700
RECEIVE A WIRELESS FRAME, THE FRAME HAVING A FIRST NODE AS A FRAME SOURCE AND A SECOND NODE AS A FRAME DESTINATION
702
TFO APPLICABLE ?
N
Y
704
TRANSCODE THE FRAME
708
SID FRAME ?
N
Y
710
SIDS COMPATIBLE ?
Y
N
712
CONVERT THE SID FRAME FROM THE SID FORMAT USED BY THE SOURCE NODE TO THE SID FORMAT USED BY THE DESTINATION NODE
706
SEND FRAME TO FRAME DESTINATION

FIG. 7



708
710
800
DETERMINE THE SID FORMAT USED BY THE SOURCE NODE
802
SID FORMAT ?
2G_EFR_SID
3G_EFR_SID
804
CREATE OUTPUT SID FRAME FROM 3G FRAME TEMPLATE
808
CREATE OUTPUT SID FRAME FROM 3G FRAME TEMPLATE
806
MAP 2G SID FRAME PAYLOAD BITS (S) INTO 3G FRAME TEMPLATE BITS (P): COPY S1-S38 TO P1-P38 COPY S87-S91 TO P39-P43 LOAD RFCI FIELD WITH VALUE INDICATING SID FRAME
810
MAP 3G SID FRAME PAYLOAD BITS (P) INTO 2G FRAME TEMPLATE BITS (S): COPY P1-P38 TO S1-S38 COPY P39-P43 TO S87-S91 FILL S39-S86 WITH GSM_EFR_SID CODEWORD
712

FIG. 8

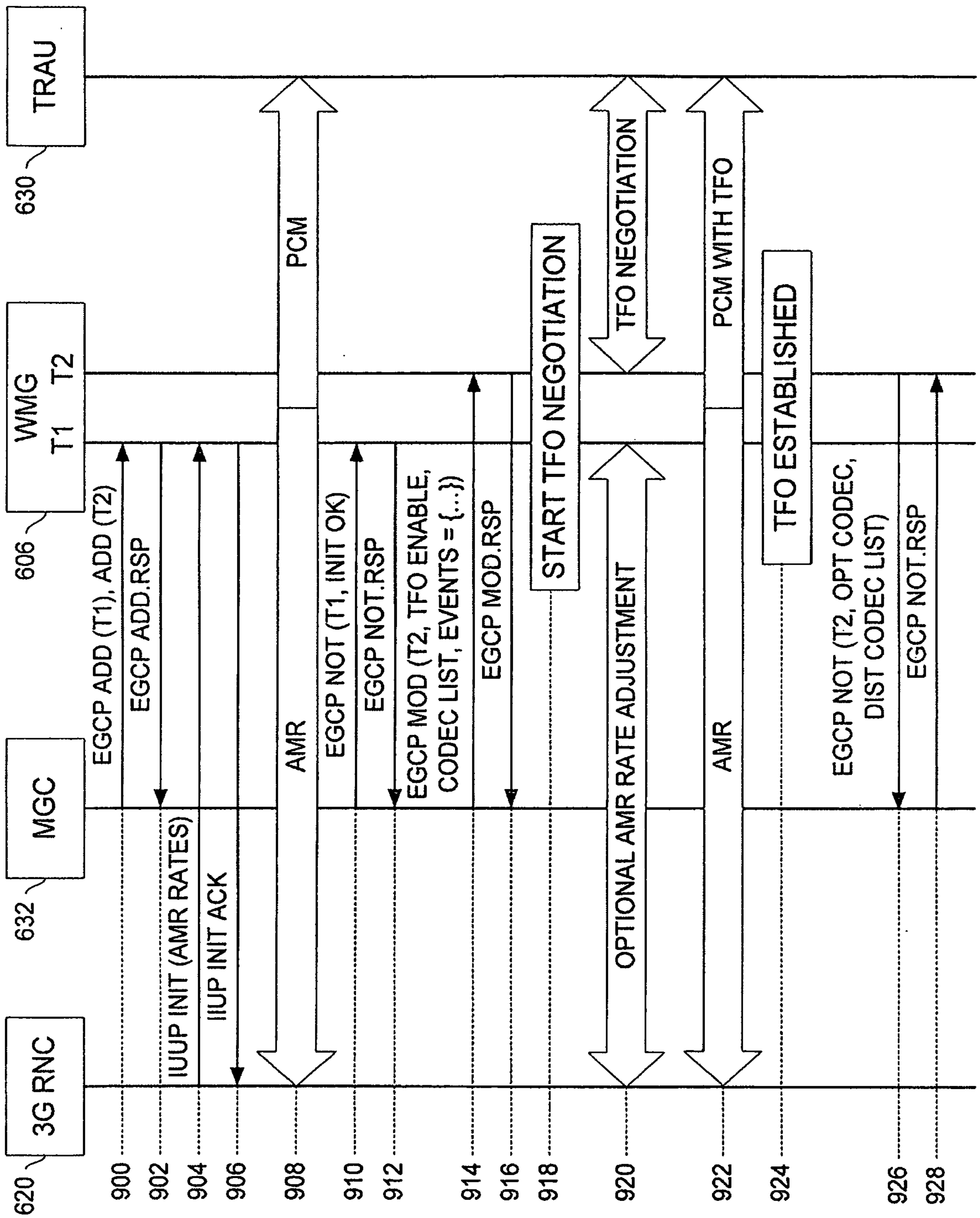

TRAU
630
WMG
T1 T2
606
MGC
632
3G RNC
620
EGCP ADD (T1), ADD (T2)
EGCP ADD.RSP
IIUP INIT (AMR RATES)
IIUP INIT ACK
AMR
PCM
EGCP NOT (T1, INIT OK)
EGCP NOT.RSP
EGCP MOD (T2, TFO ENABLE, CODEC LIST, EVENTS = {...})
EGCP MOD.RSP
START TFO NEGOTIATION
TFO NEGOTIATION
OPTIONAL AMR RATE ADJUSTMENT
AMR
PCM WITH TFO
TFO ESTABLISHED
EGCP NOT (T2, OPT CODEC, DIST CODEC LIST)
EGCP NOT.RSP
900
902
904
906
908
910
912
914
916
918
920
922
924
926
928

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 07/26413

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H01L 29/08 (2008.01)
USPC - 455/414.4
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - H01L 29/08 (2008.01)
USPC - 455/414.4

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 455/403, 414.1, 414.4, 432.2, 452.2; 370/310, 312, 332, 395.21

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST(PGPB,USPT,USOC,EPAB,JPAB); Google Scholar
Search Terms Used: silence insertion descriptor, tandem-free operation, node, point, frame, speech compression, 3G, conversion, wireless, cellular, comfort noise etc.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2005/0084094 A1 (Gass et al.) 21 April 2005 (21.04.2005), para. [0031], [0037], [0041]	1-15
Y	US 2004/0110539 A1 (El-Maleh et al.) 10 June 2004 (10.06.2004), para. [0023], [0032]	1-5, 10-15
Y	US 2001/0043577 A1 (Barany et al.) 22 November 2001 (22.11.2001), para. [0131], [0133]	3, 4, 6-9, 12, 13
Y	US 2004/0133419 A1 (El-Maleh et al.) 8 July 2004 (08.07.2004), para. [0028]	5, 9, 14

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 April 2008 (03.04.2008)	29 APR 2008

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774